(NASA-CR-140107) LARGE SCALE FIRE TESTING OF AIRCRAFT INTERIOR CONSTRUCTION AND THE DEVELOPMENT OF CRITERIA TO REPRESENT THE LEVEL OF THREAT Quarterly Progress Report, (California Univ.) 13 p

N74-76147

Unclas
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LARGE SCALE FIRE TESTING OF AIRCRAFT INTERIOR CONSTRUCTION AND THE DEVELOPMENT OF CRITERIA TO REPRESENT THE LEVEL OF THREAT

NASA-NSG 2026

Quarterly Progress Report

May-July 1974

by

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0. FOREWARD

This report is the first quarterly report on this project covering the period May-July 1974. During this period the University of California group has been primarily concerned with acquiring an appreciation of the major factors affecting the fire safety of aircraft interiors. Consequently, the major thrust of this first period of work has been involved with literature reviews, interaction with airframe manufacturers, drafting and redrafting work plans and exploratory preliminary testing. This report will discuss the progress achieved in these areas. It is expected that,if there are questions concerning any points made herein, they will be made known to the Principal Investigator within a reasonable time following the receipt of this report. If no questions have been raised before October 1, 1974, it will be assumed that this report has been accepted.

1. INTRODUCTION

1.1 It is taken as self evident that the fire safety of passenger aircraft interiors must be considered in a manner consistent with similar interior spaces in other vehicles and in buildings. For instance, the safety of the passengers on board a "wide-body" aircraft, such as the Boeing 747, the McDonald-Douglas DC-10 or Lockheed L1011, should be consistent with the fire safety on board a ship or in a movie theater with an equal number of occupants. It is evident from our first quarter's work that this is not necessarily the case. It appears very likely that the aircraft passenger is at considerably more risk than a passenger on board a water-bound American Flag vessel or in the audience of a movie theater in an American city. It should be pointed out, however, that there were major ship and theater fires that were responsible for toughening the fire regulations for those occupancies (see McDaniel 1973). One of the principal objectives of this research project is to establish large scale testing procedures for the evaluation of aircraft interiors so that improvements in safety can be achieved without a tragic accident.

1.2 In evaluating the fire safety of any structure it is essential to divide the overall problem into a number of components. There are a number of concerns involved in preventing ignition of the first object(s) in the fire scenario and there are another set of concerns involved in managing the fire impact, given the sustained ignition of one or more objects. In this project we are principally concerned with the latter problem, that of evaluation of fire impact, although the results may well have important implications on fire prevention practices on board aircraft.

1.3 The evaluation of fire development in aircraft is very similar to that in other structures and, as noted above, the final criteria may be similar. This project is focusing on the large scale testing of aircraft lavatories, but lavatories are considered to be models of larger aircraft compartments. They have their own importance since they are areas which receive only intermitent supervision and thus are a possible location of an undetected fire, but they also represent a smaller version of the typical aircraft interior space. During the past 30 years in numerous laboratory studies there have been many tests conducted on model compartments and there is a considerable literature on this topic. It is our intention to consider the lavatory tests both as a full scale test of the component and as a model of the larger cabin spaces. This leads us to discuss the fire development inside the lavatory compartment in terms that can be utilized to analyse the other spaces on board the air craft.

2. PROGRESS STATEMENT

As noted in the Foreward, the principal activities have been primarily concerned with defining potential problems of aircraft interior materials and the development of a framework of concepts that will allow a realistic test program. The major thrust of this first period of work has been involved with literature reviews, interaction with airframe manufacturers, drafting and redrafting work plans and exploratory preliminary testing. This report will discuss the progress achieved in these areas.

2.1 Review of Literature

In the first quarter of this project, the University of California has concentrated on literature essential to increasing its data on probable ignition sources in aircraft interiors. A few of the topics under study are:

a. aircraft fire case histories
b. fire test reports on aircraft (by others)
c. polymer research and development
d. past research in related topics.

2.2 Interaction with Individuals and Groups

2.2.1 A primary source of information has been gained through interaction with the individuals and groups related to many facets of this research project. For example, a variety of interests were represented at the NASA-Ames Research Center on May 15, 1974 in the "Conference on Aircraft Interior Fire Protection."

2.2.2 More specific contact has been made with other individuals such as a fire safety engineer for a major commercial air carrier.

He has been most informative in many practical matters. He has shown our group past aircraft fire test films, provided us with accident and test reports, discussed problem areas, and generally made his expertise available to us.

2.2.3 In addition, a great deal of practical insight was obtained from our visit to the Boeing Aircraft facility in Seattle, Washington on June 12, 1974. The purpose of this trip was generally to inspect Boeing's facilities and to exchange ideas and information with their engineers. The following is an outline of the events which occurred:

a. presentation by the Boeing staff of their planned tests and long range objectives,

b. discussion by U.C. concerning test plans and an overview of U.C. thought,

c. comparison of time tables, concepts and long range problems,

d. determination of what exchange of facilities, equipment, and data was feasible,

e. inspection of actual wide-bodied jet lavatory module,

f. inspection of mock-up interiors of several state of the art Boeing jets,

g. inspection of Boeing 747 research aircraft.

2.2.4 It is unclear who is responsible for the acquisition of the aircraft refuse to be used in testing; this responsibility must be ascertained.

2.2.5 The result of our visit to Boeing was an increased awareness of several potential problem areas. These areas include non firestopped voids behind wall panels and polymeric ceiling panels found in the Boeing 747. These panels span approximately five feet, are supported at the edges by light gage aluminum channels, and are held in place with plastic clips. The fact that in the front of the plane there is no barrier between these panels and the flight deck forced the University of California to reassess the importance of flight deck protection. This will be discussed at more length in a future progress report.

2.3 Work Plan.

Utilizing the information obtained from the sources mentioned previously, in conjunction with our knowledge and experience in fire testing, we have prepared the following workplan:

2.3.1 Task I

Analyze the burning characteristics of the University of California 1.75 gallon (7.95 liter) polyethylene wastebasket ignition source (in U.C. compartment) in relation to:

a. weight loss vs time,

b. temperature vs time,

c. heat flux vs time,

d. height of flame vs time,

e duration of actual fire.

2.3.2 Task II

The simulation of wastebasket fire (in U.C. compartment) using a gas burner attempting to characterize the following factors:

a. temperature vs time,

b. heat flux vs time,

c. flame height vs time.

(This will indicate if it is possible to approximate all or some of these parameters with a fire simulator.)

2.3.3 Task III (Additional)

Analyze the burning characteristics of potential aircraft ignition source/fuel load in U.C. compartment.

a. Objective: to determine one possible realistic ignition source and fuel load which may be found in commercial aircraft, and to characterize its burning in U.C. compartment.

b. Collection of representative ignition source/fuel load (by whom?).

c. Measurements will be taken of the same factors previously analyzed for the wastebaskets.

2.3.4 Task IV.

Simulation of the aircraft ignition source fire with approved ignition source in our compartment.

a. Procedure identical to that of wastebasket fire simulation.

2.3.5 Task V. (Additional)

Duplication of compartment tests in NASA's plywood modules with the door open.

a. Approximation of mechanical ventilation parameter existing in actual aircraft lavatory module.

b. Plywood modules fitted for instrumentation, camera angle, etc. in anticipation of actual lavatory modules.

c. Characterization of burning of realistic aircraft ignition source.

d. Approximation with fire simulator.

2.3.6 Task VI (Additional)

Tests of representative aircraft interior materials in compartment and/or plywood modules, using fire simulator calibrated to realistic ignition source. These interior materials will be not only parts of the lavatory interior but also interior parts of the main body of the aircraft. Measurements recorded throughout these tests will be:

a. temperature vs time,

b. observed time of ignition and rate of flame spread,

c. time to flashover (point at which the average temperature read by all ceiling thermocouples is 500°C),

d. photographic record - both still and motion picture,

e. gas grab samples,

f. light obscuration readings.

2.3.7 Task VII

Tests of actual wide-bodied jet lavatories using fire simulator calibrated to realistic ignition source.

a. Essentially the same parameters will be measured as per Task VI.

2.3.8 Task VIII

Final report.

2.4 Discussion of Work Plan and Progress to Date.

In order to perform reproducible controlled testing for this project, ignition sources must be devised, capable of simulating a prescribed fire scenario for a number of tests. Furthermore, to make the test(s) relevant, this ignition source should be a controllable source which could be "programmed" to follow the course of a representative ignition source and fuel load found on commercial aircraft. The people representing the NASA-Ames Research Center proposed that a gas burner fueled by propane be used. Because the phenomenon of fire involves a number of dynamic factors influencing its course, the task of approximating a given fire with a gas burner is a difficult one. In order to simulate a given fire satisfactorily, factors such as temperature, weight loss, heat flux, etc. (which all vary with time) must be known. This involves a great deal of preliminary testing with a control ignition source. For this reason we have chosen our U.C. 1.75 gal., polyethylene wastebasket ignition source ignited in a compartment. In our laboratory numerous compartment tests have been performed with this source and, therefore, considerable background data has been accrued.

2.4.1 Task I.

At this time we have completed the testing in Task I and are presently analyzing the data generated. The testing involved the controlled burning of twenty-one 1.75 gallon wastebaskets each containing twelve one quart milk cartons (6 standing and 6 shredded). The data recorded was weight loss vs time, flame height vs time, and temperature varying with time. A photographic record of 35 millimeter color slides was taken at intervals varying from 30 seconds to one minute throughout the duration of each test run. Heat flux measurements were not made during these tests but are planned after the data has been reduced on these tests. A preliminary review of the data shows good consistency and it appears reasonable.

2.4.2 Task II.

Although Task II cannot be executed until the raw data has been analyzed, there are several alternatives to consider as the primary factor in calibrating the gas burner. One possibility is to vary the gas flow according to a mean time-temperature curve obtained from the wastebasket fires. Another is to determine the calorific content of the weight lost at a given increment in time and relating this to gas flow. And finally, taking heat flux readings at selected areas of the compartment and using this information to govern gas flow. The procedure chosen will be the one which best approximates the other necessary elements in the fire scenario (i.e. that which produces the prescribed flame height, etc.).

2.4.3 Gas Burner

After some study, the University of California has decided that the gas burner delivered to us by NASA is inappropriate for use in this research program. Primary reasons for this decision are that the burner has inherent dimensional problems and does not produce an appropriate flame configuration. Consequently, we are currently developing an improved and more appropriate diffusion burner.

2.4.4 Procedure and Data Retrieval.

Not shown on the test plan but very necessary to this grant is the upgrading of our procedures. To more readily perform this testing program we have been modifying our instrumentation and data retrieval system. Our computer program is being expanded and upgraded to accept and print data in a more appropriate format for this project. We have also ordered a high speed paper tape punch and reader unit, essential to improving our data retrieval apparatus.

3.0 PROJECTED PROGRESS IN THE NEXT QUARTER

Based upon the current rate of progress the University of California will attempt to complete a major portion of the testing program in the forthcoming quarter.

3.1 Task II

We will be attempting to calibrate the gas burner to the wastebasket fire very shortly. Assuming this will be successful, it will be necessary to have representative ignition/fuel loads from commercial aircraft to begin Task III of the test plan.

3.2 Task III

It appears from recent contacts with NASA Ames and the Boeing Aircraft Company, that a representative ignition source has yet to be obtained. This facet of the research project is essentially a statistical one. It was the understanding of the University of California at the onset of this project, that this information would be supplied by a contractor studying past aircraft fires and their causes. That, however, seems not to be the case. Consequently, if in fact, the University of California is now responsible for this task, this will add time and expense to our budget which originally made no appropriation for this.

However, assuming we have a satisfactory source, we will analyze its burning characteristics in much the same manner as previously done for the wastebaskets.

3.3 Task IV

Task IV will be executed using the technique decided upon in Task II.

3.4 Task V

The plywood modules delivered to the University of California were not included in the original proposal. It was our understanding that one of the actual lavatory modules would be used for preliminary testing. Although this substitution superficially does not seem to change the overall scheme, it does, however, add a whole series of tests which was not anticipated. It therefore, will involve more time and expense than allotted in the original proposal.

3.5 Task VI

Task VI will most likely be the last phase of the work plan completed in the next quarter of work. It is understood that the NASA-Ames Research Center will supply the University of California with component parts of current aircraft interiors upon request. Once we have obtained these parts they will be attached to the interior of the plywood modules and tested using the fire simulator calibrated to a realistic ignition source.